

PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Making Alloy Extruded Forms by Powder Metallurgy

We, THE DOW CHEMICAL COMPANY, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of Midland, County of Midland, State of Michigan, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a magnesium-base alloy article. It more particularly concerns a tin-containing magnesium-base composite alloy having a high tensile strength and the lightness characteristic of magnesium.

The term "magnesium-base alloy" used herein means a magnesium alloy containing at least 80 per cent. magnesium by weight.

The invention is predicated upon the discovery that by die-expressing at elevated temperature a tin-containing magnesium-base alloy in particulated form in admixture with one of the magnesium-soluble metals aluminium and zinc in particulated form a high strength composite alloy extrusion is obtained. The composite alloy extrusion has the same compactness and integrity as the usual magnesium-base alloy extrusions made by extruding a solid mass, such as an ingot of a magnesium-base alloy, but the metallographic structure of the composite product is uniquely different. Metallographic examination reveals a new type of structure in a magnesium-base alloy article. The structure is essentially multi-metallic. Each of the particulated metals of the mixture which is extruded is changed to the form of an elongate particle. All the particles are oriented

in the direction of the extrusion. The elongated particles are all welded one to the other into a solid mass without voids, forming a high strength composite alloy which may be treated or worked, for example, by rolling, forging or pressing, like conventional magnesium alloys. The invention consists of the composite magnesium-base alloy product and method of making. The following description sets out several modes of practising the invention.

In carrying out the invention, various magnesium-base alloys containing tin may be used as one of the ingredients of the composite alloy, such as those containing from about 0.5 to 8 per cent. of tin; a preferred proportion of tin is about 4 to 6 per cent., the balance being magnesium. The tin-containing magnesium-base alloy is reduced to particulate form in any suitable way, such as by grinding or atomizing. The atomized form is preferred and may be produced by forming a melt of the alloy and atomizing it by causing a jet of a cool gas, e.g., natural gas, to impinge against a thin falling stream of the molten alloy. The atomised alloy consists of a mixture of various sized fine spherical rapidly solidified particles, the particles having a very fine grain structure. It is desirable to screen out particles coarser than those passing about a 10 to 20 mesh sieve.

The magnesium-soluble metal ingredient of the mixture of particulate metals to be extruded according to the invention is finely divided in any convenient manner. Its particle size preferably is made finer than that of the tin-containing magnesium-base alloy with which it is to be mixed.

Before extrusion, the particulated

metals are mixed together in any convenient manner to form a uniform mixture of the metal particles comprising the extrusion charge. The relative amounts of the particulated tin-containing magnesium base alloy and particulated magnesium-soluble metal are adjusted so that there is at least 0.1% up to as much as 6% by weight of the particulated magnesium-soluble metal in the mixture. A preferred proportion of the particulated zinc in the mixture is about 3%.

The mixture of particulated metals is charged into the heated container of a ram extruder, having a suitable size container and die opening and subjected to extrusion pressure to cause the mixture of particulated metals to be heated and extruded through the die opening.

As to the extrusion conditions, the temperature of the particulated metal mixture in the container may be about the same as that conventionally employed for extruding solid ingots of the known tin-containing magnesium-base alloys, e.g., about 600° to 800° F. The ratio of the cross-sectional area of the extrusion container to that of the die opening has a material effect on the mechanical properties of the composite extrusion product obtained. A desirable ratio is at least about 30 to 1, although ratios as high as 150 to 1 or more may be used. The speed of extrusion may be varied over a wide range and depends to some extent upon the size and shape of the die opening in any case the speed is to be held down to that at which the extrusion produced is free from hot shortness. A safe extrusion speed may be ascertained by visual examination of the product as it extrudes, the hot shortness being evident as cracks in the extruded product and sharply reduced strength. The composite extrusion product may be subjected to any of the fabrication operations in use with the conventional or non-composite magnesium-base alloys, for example, such as rolling, forging, drawing and welding. Its tensile properties may be modified by heat treatment.

The invention may be further illustrated and explained in connection with the accompanying drawing in which:—

Figure 1 shows a diagrammatic sectional elevation of an extrusion apparatus suitable for use in practicing the invention;

Figure 2 is a similar view to Figure 1 showing a modification of the apparatus; and

Figure 3 is a similar view to Figure 1 showing another modification of the apparatus.

As shown, the apparatus comprises, in its three forms, an extrusion container 1 adapted to confine a charge 2 of the mixture of metal particles to be compacted and extruded. The container is provided with a heating element 3. In Figure 1, one end of the container 1 is closed by the die plate 4 in which is provided the die opening 5. In this form of the apparatus the charge 2 is caused to be compacted in the container and extruded through the die opening 5 by application of pressure by means of the dummy block 6 forced into the bore 7 of the container by the ram 8 to form the extrusion 9.

In the form of the apparatus shown in Figure 2, the container 1 is closed at one end by the plate 10. The other end of the container received the die block 11 carried by the hollow ram 12 which forces the die block into the container causing the charge 2 to be compacted and to extrude through die opening 13 to form the extrusion 14 which extends into bore 15 of the hollow ram 12.

In the modification of Figure 3, the container is closed at one end with a plate 16. The charge 2 is extruded as a tubular extrusion 17 through the annulus 18 around the die block 19 while it is forced into the container by the ram 20.

The forms of the apparatus shown are conventional.

By putting a charge of the mixture of the metals involved under pressure while at heat, as with the apparatus shown the metal particles are compacted but not subjected to further mixing before extrusion. The metals originally in the charge as individual metal particles become welded together without voids and do not lose their original distinctive composition except at the united surfaces of the particles which become extended and lengthened during extrusion. At these surfaces, during extrusion or heat treatment, some diffusion of metal takes place between the tin-containing particles and the magnesium-soluble metal particles.

The following examples set forth in the table below are illustrative of the invention: The blank is included for the purpose of comparison.

TABLE

Example No.	(Composition of Extrusion (Charge of Particulated Magnesium Alloy (A) Mixed with Al or Zn (B))			Extrusion Temp. °F.	Mechanical Properties in 1000 psi of Extrusions*							
					ASX		Aged		H.T.		H.T.A.	
	Wt. % A	Analysis of A	Wt. % B		TYS	TS	TYS	TS	TYS	TS	TYS	TS
1	99.5	4.26% Sn, Balance Mg.	0.5% Al	620	33	42	38	44	27	37	27	56
2	97.0	ditto 100	3.0% Al	620	35	43	39	43	30	39	29	38
3	94.0	ditto	6.0% Al	620	38	42	41	44	34	41	34	43
4	99.5	ditto	0.5% Zn	670	38	45	42	37	35	44	28	38
5	97.0	ditto	3.0% Zn	670	38	47	39	45	24	38	24	38
6	94.0	ditto	6.0% Zn	620	35	43	38	45	24	31	32	42
Blank	100	ditto	none	620	32	41	35	42	25	31	25	34

* ASX = as extruded.

Aged = heat treated for 16 hours at 350° F.

H.T. = heat treated for 1 hour at 750° F.

H.T.A. = heat treated for 16 hours at 350° F. followed by heat treating for 1 hour at 750° F.

TYS = tensile yield strength defined as the stress at which the stress strain curve deviates 0.2% from the modulus line.

TS = tensile strength.

In making the composite alloys shown in the foregoing table, the tin-containing magnesium-base alloy was used in atomized form, the particles of which were of various sizes substantially all passing through a 20 mesh standard sieve but not a 200 mesh sieve. The particles of the particulated magnesium-soluble metal were of generally finer size than those of the magnesium-base alloy. The particulated metals were mixed together in the proportions indicated and the mixtures charged into the heated container of a ram extruder of the type illustrated in Figure 1. For the blank, the tin-containing magnesium-base alloy in the same particulated form as used in the mixtures was extruded alone under comparable extrusion conditions. The rate of extrusion was about 1 to 2 feet per minute. The reduction in area was 34:1. The composite alloy extrusions produced were wire 0.086 inch in diameter having a multimetallic structure of elongated particles oriented in the same direction lengthwise of the extrusion and welded together without voids.

What we claim is:—

1. The method of making a solid composite high strength metal body comprising a magnesium-base alloy containing tin which consists in forming a mixture of a magnesium-base alloy containing from 0.5 to 8 per cent. of tin, the alloy being in particulate form, and a magnesium-soluble metal consisting of aluminium or zinc, the amount of

aluminium or zinc being from 0.1 to 6 per cent. of the mixture by weight, and die-expressing the mixture in heated condition.

2. The method according to Claim 1 in which the magnesium-base alloy contains 4 to 6 per cent. of tin, the balance being magnesium.

3. The method according to Claim 1 in which the magnesium-soluble metal is aluminium.

4. The method according to Claim 1 in which the magnesium-soluble metal is zinc.

5. The method as claimed in Claim 1 wherein the die-expressed mixture has any one of the compositions set out in the foregoing table.

6. A solid composite metal body when made by the method claimed in any one of the preceding Claims.

7. A composite metal body produced by the method of any of the preceding Claims consisting of at least two particulated metals one of the two particulated metals being a magnesium-base alloy containing tin and another being a magnesium-soluble metal consisting of aluminium or zinc, the particles of each of the particulated metals being elongated, oriented in the same direction, and welded together into an integral solid.

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Sn 0.5~8

Al 0.1~6

Zn 0.1~6

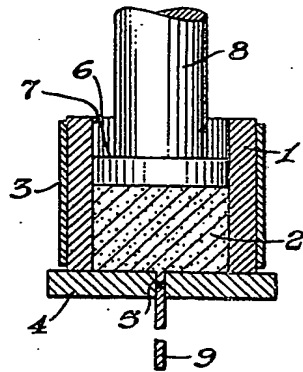


Fig. 1

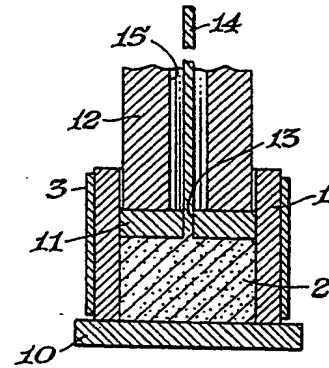


Fig. 2

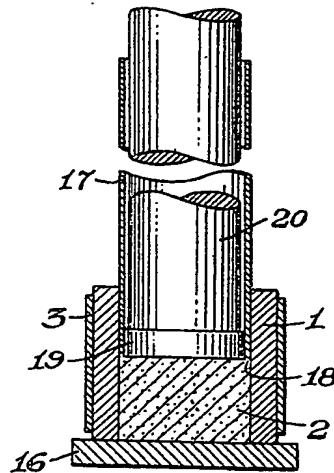


Fig. 3